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Contract MDA-903-75-C-0016

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ORI

SUMMARY DESCRIPTION OF THE [illegible]
USED FOR THE JOINT [illegible]
(LOTS) TEST AND [illegible]

28 FEBRUARY 1977

PREPARED UNDER
CONTRACT [illegible]
FOR THE OFFICE OF [illegible]
DEPUTY DIRECTOR [illegible]
OFFICE OF THE DIRECTOR, [illegible]
AND ENGINEERING
WASHINGTON, D.C. [illegible]

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SUMMARY DESCRIPTION OF THE SIMULATION MODEL
USED FOR THE JOINT LOGISTICS-OVER-THE-SHORE
(LOTS) TEST AND EVALUATION PROGRAM

28 February 1977

Prepared Under
Contract Number MDA-903-75-C-0016
For the Office of the Secretary of Defense,
Deputy, Director (Test and Evaluation)
Office of the Director, Defense Research and Engineering
Washington, D.C. 20310

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ORI Technical Report No. 1140	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Summary Description of the Simulation Model Used for the Joint Logistics-Over-The-Shore (LOTS) Test and Evaluation Program		5. TYPE OF REPORT & PERIOD COVERED Final Report Dec. 1976 - Nov. 1977 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) H. Casey, A. Green, G. Holiday, W. Sutherland		8. CONTRACT OR GRANT NUMBER(s) MDA-903-75-C-0016
9. PERFORMING ORGANIZATION NAME AND ADDRESS ~~Operations Research, Inc.~~ ~~1400 Spring Street~~ ~~Silver Spring, Maryland 20910~~		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS OSD, Deputy Director (Test and Evaluation) Office of the Director, Defense Research and Eng. Rm. 3D1080, The Pentagon, Wash. D.C. 20310		12. REPORT DATE 28 February 1977 13. NUMBER OF PAGES 23
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) N/A		15. SECURITY CLASS. (of this report) 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Contracting Officer's Technical Representative— Mr. Howard Kreiner

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Beach Handling	Containerization	Joint LOTS
Breakbulk	Containership	Lighterage
Breakbulk Ship	Crane-on-Deck	Logistics Simulation
Cargo	Cranes	Logistics-Over-The-Shore (Cont.)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents an outline description of the Logistics-Over-The-Shore (LOTS) simulation model being used in the test planning for a joint operational test scheduled for August-September, 1977. The simulation is an expected value model adapted from one used by the U.S. Army as part of the Trans-Hydro Craft Study. Results of interim test runs were used in validating and refining test concepts, resource requirements, timings, and operational procedures.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

19. Key Words (Cont.)

Logistic Support	Ship-to-Shore
LOTS Simulation	Shoreside Handling
Model	Temporary Container Discharge Facility
Ship Off-Loading	Test and Evaluation
Terminal Service	
Throughput	
Transportation	

20. Abstract (Cont.)

The model simulates a LOTS operation beginning immediately after the arrival of one or more cargo ships of various types at an off-shore site. Cargo is off-loaded to lighters which move to shoreside unloading locations and return to the ship for another load. Cargo at the shore is transferred to vehicles, and delivered to an inland destination. The simulation ends when all cargo has been transferred to an inland destination.

The model provides a capability for performing a variety of sensitivity analyses for various mixes of ship types, lighters, shoreside handling systems, materials handling equipment, and vehicles. Basic inputs include data on performance characteristics for LOTS equipment and cargo transfer times. Data inputs structure the particular system being simulated (shipside, ship-to-shore, and shoreside unloading and distribution subsystems) and the conditions under which they operate. By varying the assumed input data the effects of different environments can be simulated. By varying LOTS equipment assets changes in system productivity can be measured. The model is normally used to estimate minimum resources necessary to keep ship cranes or booms working and the total operating system in balance. Principal outputs are the total time required to off-load the ship and move cargo to a marshalling area, and the percentage utilization of the LOTS equipment (material handling equipment, lighters and trucks).

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I. INTRODUCTION

ORIGIN AND STATUS OF MODEL

The objective of using the Logistics-Over-The-Shore (LOTS) simulation model is to validate and refine the LOTS main test design. The forerunner of the present LOTS simulation model was developed to support the U.S. Army Trans-Hydro craft study.[1] That model was designed jointly by the USACDC Systems Analysis Group and the USACDC Transportation Agency.[2] A review of the Trans-Hydro model indicated a need for improvement in the realism of certain features and to enlarge its capabilities for simulating a total LOTS cargo throughput system. Additionally, changes were made to improve its efficiency in the use of computer time. Following model updating and reprogramming, a number of sensitivity analyses were conducted.

Overview of Model

The LOTS model follows an operational sequence as depicted in Figure 1. The simulation begins immediately after the arrival of each of one or more cargo ships off-shore, tracks the movement of cargo— specified as to quantities and kinds— across a beach, and ends with the delivery of all the cargo to a marshalling area.

For analyses the principal model outputs are the total time for unloading cargo, moving cargo ashore to a marshalling area, and resource productivity. A minimum time for unloading results when the system is in balance. This is

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[1] United States Army Training and Doctrine Command, Transportation School, U.S. Army Trans-Hydro Craft Study 1975-85, December 1973.

[2] United States Army Combat Developments Command Systems Analysis Group, Logistics-Over-The-Shore (LOTS) Simulation Model Documentation, SA Group Technical Report TR 14-72, July 1972.

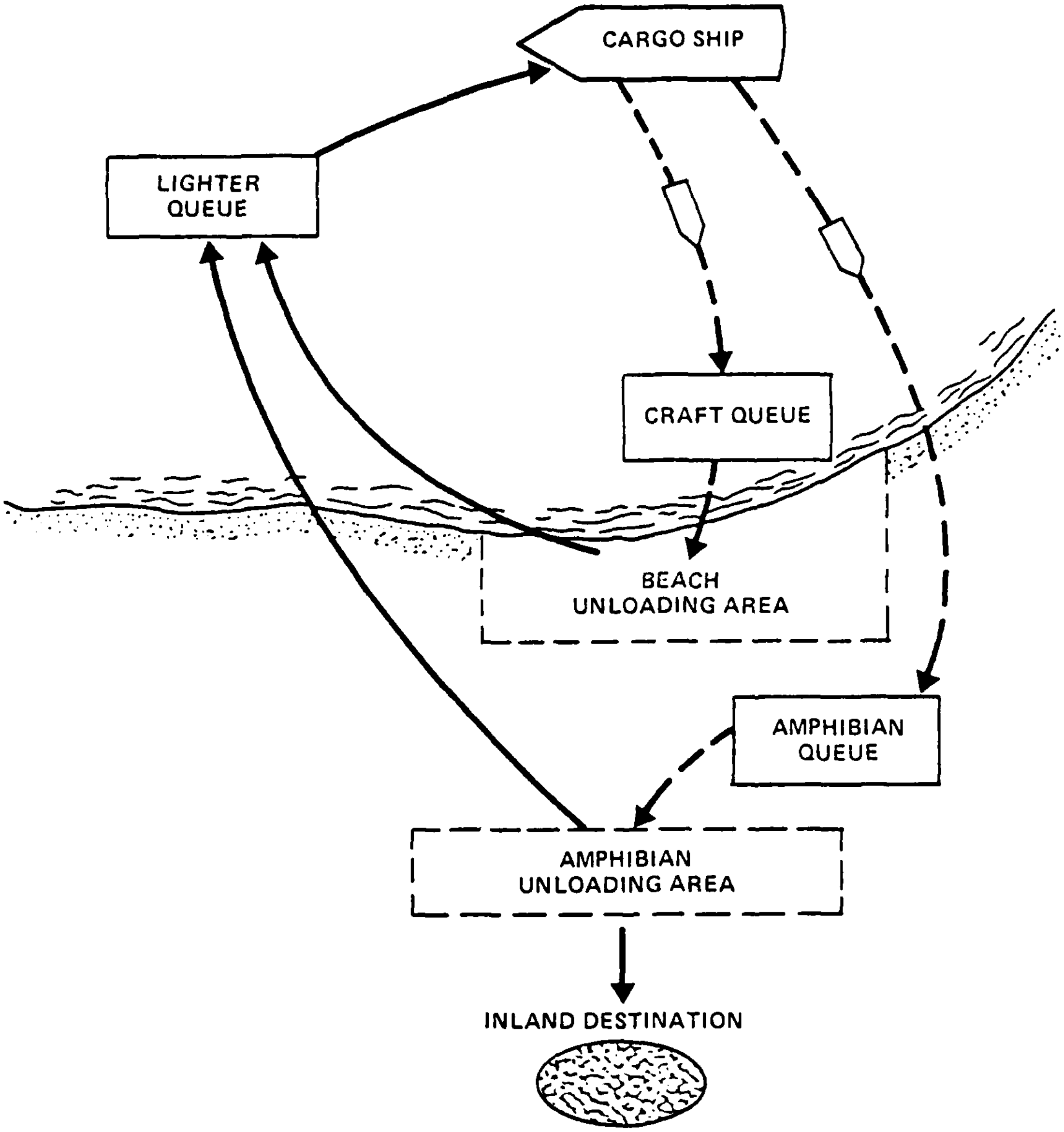

FIGURE 1. OPERATIONAL SEQUENCE OF LOTS MODEL

dependent upon the input selections. That is, when the ship unloading rate is specified and sufficient transportation and handling assets are available at all times, the minimum time for moving the cargo ashore is the time for all the cargo to be discharged from the ship plus the time it takes the last piece of cargo to move from the ship to the marshalling area. If there is any time spent waiting for lighters or access to equipment such as the beach crane, the total time increases. Thus, the model is usually used starting with too few assets, particularly transportation assets, which results in a greater than minimum time. Then in succeeding runs the assets are agumented until a minimum time is achieved. Except for additional ship cranes any further increase in assets, of course, could not reduce this minimum time.

The model is an expected value model that makes straightforward calculations based upon fixed values input by the analyst.

The results of a series of model runs are currently being used in the on-going LOTS test planning. They are presented in t[illegible]in test design report[3] and examples are repeated in this report to il[illegible]ate how the model is used.

Model Improvements

A number of changes were made to the Trans-Hydro model so it could better simulate the operations scheduled for the joint LOTS test. The more significant changes are discussed below.

In the original model only one crane was programmed to discharge the non-self-sustaining containership. Up to three cranes can now be modeled to off-load the containership. This modification was made because two cranes (two cranes-on-deck or two temporary container discharge facilities) are planned to discharge the containership. Also, in the final phase of the test a third crane will be employed to increase the discharge rate from the ship. The increased discharge rates require more lighters and provide insights on capabilities of shoreside subsystems.

In discharging the containership, two important operating times were added to the Trans-Hydro model. One is the time required to reposition cranes used to off-load the containership. The other is the time to remove and replace hatch covers.

The routine used in the original model to select the next container to be off-loaded from the ship was also reprogrammed. Now when the weight of the next container in the cell being off-loaded exceeds the remaining weight capacity of the lighter, the containers at the top of the other cells in the hatch are checked for a container within the capacity of the lighter.

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[3] Operations Research, Inc., Comment Draft Report on Main Test Design of the Joint Logistics-Over-The-Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 1132, 30 January 1977, Appendix D.

If an appropriate container is found, it is loaded on the lighter. If not, then the partially loaded lighter proceeds to shore.

Another change from the original programming is to divide the crane cycle into two parts. One part of the cycle proceeds in the absence of a lighter moored alongside the ship. The other part requires a lighter and if a lighter is not present, the cycle stops. Thus the first part of the crane cycle continues during part or all of the time during which a full lighter unmoors and an empty lighter moors at the containership.

COMPUTER REQUIREMENTS

The program is currently run on an IBM 360/65 computer. The model requires 240K bytes of core and the execution time is about 1.5 minutes. The program is written in standard ANSI (X3.4-1966) FORTRAN, so only minor programming changes are required to convert the model to a different computer that has sufficient storage capacity and supports FORTRAN. As currently used, run results are available the next morning after entering a normal run and within 4 hr for a priority run.

II. MODEL DESCRIPTION

The model provides a basic operational framework which is described first. Specifics for the selected LOTS system elements are described next with input data. These inputs include the characteristics of the LOTS equipment, ship types, cargo and performance parameters, including estimates of weather effects. Model outputs and computer requirements are discussed last.

OPERATION OF THE MODEL

Lighter Use

As the simulation begins, lighters are selected from a lighter holding point, or queue[1] located near the ship. The queue can have a mix of lighters. Lighter selection is based on priorities defined in the input data. The queue discipline is such that lighters with the highest priority (and later the highest priority and the most utilization) are called first. This assures that previously unused lighters are called from the queue only when needed and thus allows unused and marginal lighters to be identified. When a lighter is selected, it proceeds to the ship and moors. It is then ready for the loading process to being. If no lighters are available, the ship crane(s) waits. After each item is loaded on the lighter, the lighter record of time, weight and volume is incremented and the ship load is decremented. For each lighter two capacity measures are used while loading containers. The first is the number of containers the lighter has space for and the other is its maximum weight capacity. Neither capacity can be exceeded. For general cargo, weight and volume capacities are used in the same way as containers. An exception is vehicle cargo for which weight and square feet of

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[1] The holding points for lighters in the model are called queues. They are not, however, the result of variability in serving rates, such as the waiting lines investigated in queuing theory.

floor space are used. No cargo can be stowed on top of vehicles in the same stowage location.

When the lighter is full, it travels to one of two possible queues near the shore. Landing craft travel to a queue located just off the shore, and amphibians go to a queue on land. Both types of lighters remain in their queue until an unloading space becomes available. After arriving at an unloading point, the lighter is off-loaded. The model keeps track of the cargo that was initially loaded on the lighter. This cargo is off-loaded one item at a time. The record of lighter time is incremented and the cargo remaining on board the lighter is decremented. The record of cargo on shore is correspondingly increased. The empty lighter returns to the queue near the ship.

Ship Unloading

In the ship unloading subsystem, there is provision for five ship types: non-self-sustaining containership, breakbulk general cargo ship, self-sustaining containership, RO/RO ship, and a LASH ship. For the LOTS main test only three ships will be employed: a non-self-sustaining containership, a breakbulk ship, and a LASH ship. The way the LOTS model simulates the unloading of these three ship types is described in the following paragraphs.

Non-Self-Sustaining Containership. In the model the non-self-sustaining containership is divided into cargo hatches, and each hatch is subdivided into container cells. Each cell has several levels with a container at each level. The number of hatches, and cells, and the levels within each cell are specified in the inputs. Only the containers in the uppermost level of each cell are accessible to the crane.

Each container has a specified weight. If a lighter has the deck space to carry another container but the next container in the cell being unloaded esceeds the weight capacity of the lighter, then a sequential search is conducted of the containers in the cells in the same hatch and specified in the input as accessible. If a container within the weight capacity of the lighter is found, it is loaded aboard the lighter. In the event all accessible containers in the hatch are too heavy, the lighter casts off and proceeds to shore.

Two types of cranes are simulated for the unloading of a non-self-sustaining containership: the crane-on-deck and the temporary container discharge facility. In the model the cranes are specified by their container transfer rate, number of hatches discharged from one location, time to reposition the crane, and times to remove and replace hatch covers.

Average container transfer times are input to the model. Several values of these container transfer times can be specified for any one run of the model. In this way the time to transfer a container to a lighter can be specified for each lighter type and container weight.

Breakbulk Ship. In the model a general cargo ship is also separated into cargo hatches. Each cargo hatch has decks. The decks are numbered sequentially and must be unloaded in order, with the uppermost deck unloaded first. All cargo must be removed from the uppermost loaded deck before any cargo from the next lower deck can be removed.

In the input each item of cargo on a deck is assigned an access number which is made to correspond to an area on the cargo decks. Each such access number can be applied to a mix of cargo. The cargo in the center of the hatch is assigned the lowest access number, and the access numbers increase as the distance from the center of the hatch increases. The cargo with the lowest access number is extracted first. This corresponds to removing the cargo first from the square of the hatch. There is no change in cargo unloading rate with access number.

Selection of cargo to be unloaded is based not only on the lowest access number still containing cargo but also on the amount of cargo capacity left in the lighter. If a craft is partially loaded and each of the items of cargo at the lowest access level exceeds the remaining capacity of the lighter, then the cargo at the second lowest access number is checked. In the event all the cargo within the two lowest access number areas exceeds the remaining capacity of the lighter, the lighter casts off and proceeds to shore.

A regular and a heavy-lift boom are modeled. The quantity, locations and capacities of the booms are specified in the input data. The heavy-lift boom on a typical cargo ship has a 60-long ton capacity and the regular cargo booms have a 15-long ton capacity. On the general cargo ship modeled the heavy-lift boom serves both cargo hatches two and three. The time to rerig the heavy-lift boom from hatch to hatch is an input.

The times to remove hatch covers on the weather deck and the hatch covers between decks are inputs. Each type of cargo has a transfer time associated with it which may differ for each type of lighter.

The model provides for simultaneously working all hatches on a general cargo ship. Each hatch can be discharged to lighters on both sides of the ship. When off-loading a hatch to both sides of the ship, unloading times were increased 20 percent over the crane cycle time used in discharging to only one side, again specified as part of the input.

An important calculation in the model concerns the locations of lighters along the side of a general cargo ship. Some lighters are longer than a cargo hatch. The number of hatches blocked by each lighter type is in the input data. When a lighter is full and casts off, a calculation is made to determine the space available to moor the next lighter. If the lighters in the queue waiting to be loaded exceed the length of space at the ship, the space remains unoccupied.

There are two ways for a new lighter to be assigned to the unoccupied hatch. First, a lighter leaves an adjoining hatch and this provides the required length of space for a lighter in the queue to moor. The other way is for a shorter lighter to arrive. A lighter occupying two hatches receives cargo from both hatches.

LASH Ship. As modeled, the LASH ship discharges barges at a rate that is specified in the input data. LASH barges are stored in a holding area located off-shore until appropriate shoreside resources become available to unload them. Barges are moved to a pier at the shore for the unloading of general cargo or containers.

Shore Cargo Transfer Operations

A lighter travels from the ship to one of the two shoreside queues. Landing craft go to a queue just off the beach and amphibians to an inland queue. Each lighter waits its turn in the queue until a crane or other material handling equipment is available to unload it. Of course, a lighter arrives at an unloading site with the same cargo that was loaded on it at the ship.

At a lighter unloading site, cargo is removed one item at a time. The time to transfer each item to a truck or the ground is specified in the input data for each type of lighter unloading site, by craft and cargo type. When applicable, the time to moor and unmoor (dock and undock) a craft at an unloading site is also part of the input data. Again, these input times can vary for the different combinations of craft, cargo and unloading sites.

INPUTS

General

Performance data currently used as inputs to the LOTS model were obtained primarily from actual performance data or from performance estimates. The speed and capacity for an LCM8, for example, are based on actual performance. For new equipment, like the LACV-30, or for new procedures such as moving the new crane-on-deck platform, or for the effects of sea states on operations, data inputs are based on available published official estimates or data supplied by the sponsoring service.

Performance Data for Lighters

Data on six types of lighters are currently standard inputs to this model. They are the causeway ferry, the LACV-30, the LARC-LX, the LARC-XV, the LCM8 and the LCU. Lighter speeds assumed for varying sea conditions are given in Table 1. The assumed speeds of the LACV-30, the LARC-XV, and the LARC-LX on land are shown in Table 2. The number, location, and orientation of containers carried by each of the above lighters in a typical LOTS operation is illustrated in Figure 2. With fuel for 2 hr of operation the LACV-30 has a design payload of 30 short tons. The payload decreases to 27.3 short tons with 5 hr of fuel and to 23.7 short tons for 9.1 hr of fuel. These maximum payloads impact directly on the capability of the LACV-30 to transport containers, in some circumstances limiting the load to one container.

TABLE 1

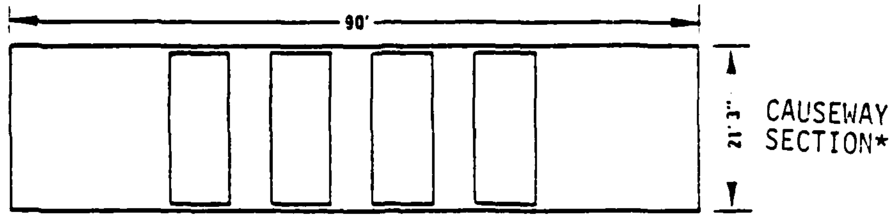
LIGHTER SEA SPEEDS

	Speed (knots)							
	0-3-Ft Sea		3-5-Ft Sea		5-8-Ft Sea		>8-Ft Sea	
Lighter	Empty	Loaded	Empty	Loaded	Empty	Loaded	Empty	Loaded
Causeway Ferry	5	3	–	–	–	–	–	–
LACV-30	50	42	45	40	32	28	25	20
LARC-XV	8	7	5	4	No Go	No Go	No Go	No Go
LARC-LX	6.6	6.2	5.3	4.8	3.5	3	No Go	No Go
LCM8	11	9	10	8.5	5	3	No Go	No Go
LCU	8	6.5	7	6	5.5	5	2.5	2

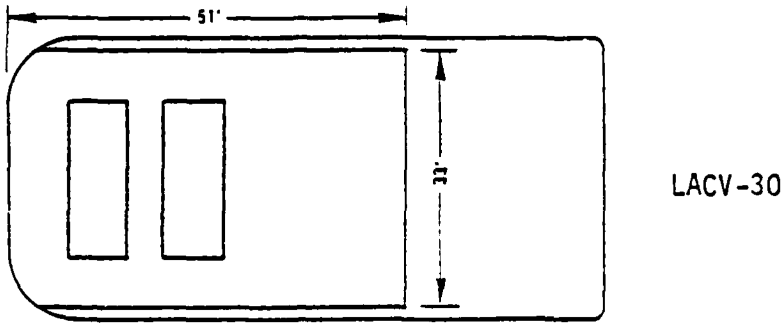
TABLE 2

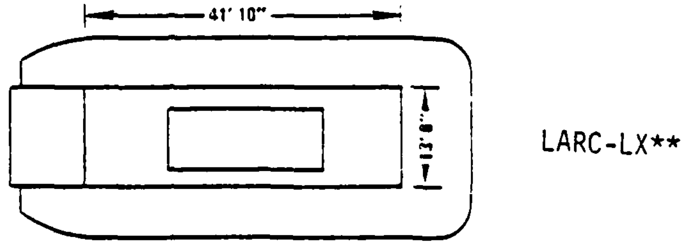
AMPHIBIAN SPEEDS ON LAND

	Speed (mph)	
Amphibian	Empty	Loaded
LACV-30	30	30
LARC-XV	15	15
LARC-LX	15	14

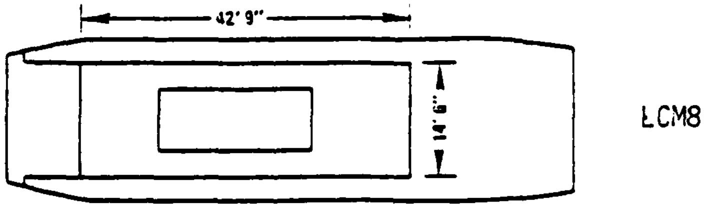


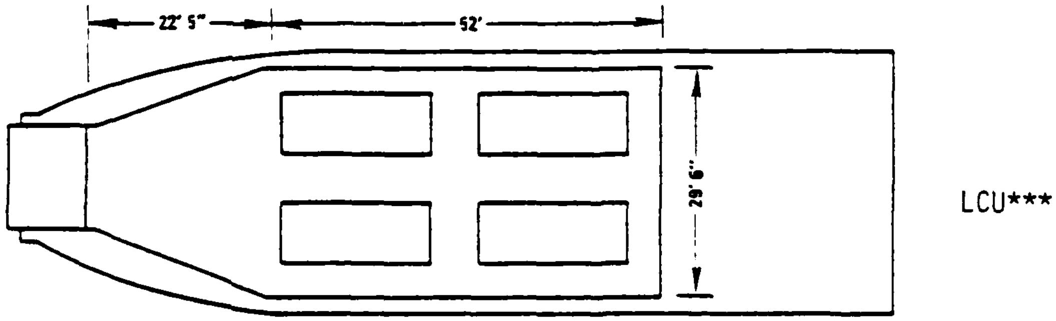
* A four section causeway was used in the model.





** The LARC-XV carries one container weighting up to 15 short tons.





*** The 1466 class LCU is shown in the diagram. The 1646-class also carries four containers in the model.

FIGURE 2. NUMBER AND PLACEMENT OF 20-FOOT CONTAINERS CARRIED BY TYPE OF LIGHTERS

The breakbulk capacity of the LARC-XV, the LARC-LX, the LCM8 and the LCU are shown in Table 3.

TABLE 3

LIGHTER CAPACITY FOR BREAKBULK CARGO

Lighter	Payload (Short Tons)	Floor Space (Sq Ft)	Volume (Cu Ft)
LARC-XV	15	324	1,134
LARC-LX	60	574	3,800
LCM8	60	620	4,134
LCU	180	1,855	14,840

The time assumed to be required to moor and unmoor the various lighters at the ship are in Table 4. Note that, as described later, the model allows for a part of the crane cycle to overlap the mooring and unmooring times. This input aspect will be studied in some detail during the main LOTS test and can have a substantial effect on the system throughput rates.

TABLE 4

MOORING AND UNMOORING TIMES FOR LIGHTERS AT THE SHIP

	Time (Minutes)	
Lighter	Mooring	Unmooring
Causeway Ferry	5	2
LARC-XV	2	2
LACV-30	1	1
LARC-LX	2	2
LCM8	2	2
LCU	5	2

Performance Data for Trucks

Three types of truck transport may be selected. They are: the container chassis with a prime mover, the M127 trailer with a prime mover, and a prime mover alone. The container chassis with prime mover carries two 20-ft containers and travels at 15 mph loaded and 20 mph empty. The M127 trailer carries general cargo. It has a weight capacity of 12 short tons, and with a prime mover travels at 10 mph both loaded and empty. The prime mover alone is used to tow non-self-propelled vehicles at a speed of 10 mph.

Performance Data for Cargo Transfer at the Ship

The cycle time to transfer a container from a non-self-sustaining containership to a lighter is taken as 5 minutes. The transfer time is separated into two elements. The first is called the lighter independent part of the cycle, and this part of the cycle takes place while a lighter is mooring. For example, the crane swings inboard, lowers the spreader bar, attaches the spreader bar to a container, and swings outboard. The time for the lighter independent part of the transfer cycle is 3 minutes. The lighter dependent part of the cycle involves placing the container in the lighter, and it requires 2 minutes. The above times are used for both the crane-on-deck and the crane-on-barge. The time to remove or replace a hatch cover is taken as 15 minutes. The time includes removing the container spreader bar, attaching the hatch cover sling, moving the cover, and then replacing the hatch cover sling with the spreader bar.

The time to transfer cargo from a general cargo ship depends on the type of cargo. Fifteen minutes is used for lifts over 10 short tons, whether general cargo, self-propelled vehicles, or non-self-propelled vehicles are being off-loaded. Ten minutes is input for self-propelled vehicles and non-self-propelled vehicles under 10 tons. Ten minutes is also used for each general cargo lift between 5 and 10 tons. Five minutes is used for general cargo that is less than 5 tons. The time to remove a hatch cover or the cover between decks is taken as 5 minutes.

Performance for Cargo Transfer at the Beach

To discharge containers from wheeled amphibians and air cushion vehicles a P&H 9125 crane is used. It may be located either just beyond the beach or in the marshalling area. The container cycle time for the inland crane is taken as 3½ minutes.

The beach crane (P&H 6250) discharges containers from landing craft. A cycle time of 5 minutes is used.

The elevated causeway off-loads containers from landing craft and the causeway ferry. A rate of 15 containers an hour or one container every 4 minutes is assumed. The above rate includes mooring, unmooring, and warping of the lighters.

The light-weight amphibious container handler (LACH) unloads containers from landing craft. It is a developmental item for which a 10-minute per container off-loading rate is assumed.

General cargo and pallets can be removed from landing craft by forklifts. For each lift a cycle time of 5 minutes is used. Trailers as cargo are off-loaded from landing craft by prime movers and a 5-minute transfer time is used. Self-propelled vehicles are driven off the landing craft and travel to the marshalling area at a speed of 10 mph.

Performance Data for Marshalling Yard Cargo Transfer

For off-loading trucks or trailers in the marshalling area, a cycle of 3 minutes is used for each container and 5 minutes for each lift of general cargo.

Cargo Description Data

A total of 38 different cargo items may be selected, as listed in Table 5. There are five weights for loaded containers plus one empty container. All other items are breakbulk. The latter include vehicles, general cargo and pallets.

TABLE 5

SIMULATION CARGO DATA

	Cargo Description	Weight (Short Tons)	Volume (Cu Ft)	Floor Space (Sq Ft)
1	Container	23.5	1,280	
2	Container	19.5	1,280	
3	Container	14.5	1,280	
4	Container	9.5	1,280	
5	Container	6.0	1,280	
6	General Cargo	60.0	3,301	
7	Self-Propelled Vehicle	50.6		290
8	Non-Self-Propelled Vehicle	46.6		239
9	General Cargo	32.8	3,402	
10	Self-Propelled Vehicle	21.2		223

TABLE 5 (Cont.)

	Cargo Description	Weight (Short Tons)	Volume (Cu Ft)	Floor Space (Sq Ft)
11	Non-Self-Propelled Vehicle	18.8		235
12	Self-Propelled Vehicle	15.0		196
13	General Cargo	11.2	2,621	
14	Self-Propelled Vehicle	10.5		176
15	Self-Propelled Vehicle	7.1		188
16	Non-Self-Propelled Vehicle	7.0		104
17	General Cargo	4.2	529	
18	Self-Propelled Vehicle	3.4		103
19	Non-Self-Propelled Vehicle	2.7		108
20	General Cargo	2.5	528	
21	General Cargo	1.7	541	
22	General Cargo	1.4	225	
23	Non-Self-Propelled Vehicle	1.4		95
24	Self-Propelled Vehicle	1.2		63
25	Pallet	1.0	60	
26	General Cargo	0.8	195	
27	Non-Self-Propelled Vehicle	0.7		72
28	General Cargo	0.6	245	
29	Non-Self-Propelled Vehicle	0.3		49
30	General Cargo	0.3	107	
31	General Cargo	0.3	72	
32	General Cargo	0.2	41	
33	General Cargo	0.2	28	
34	General Cargo	0.1	18	
35	General Cargo	0.1	17	
36	General Cargo	0.1	4	
37	General Cargo	0.1	9	
38	Empty Container	2.0	1,280	

System Descriptive Data

Different LOTS system elements may be simulated, so the inputs can change from run to run. For "bare beach" operations[2], the LACV-30, the LARC-LX, and the LCM8 are usually selected as the lighters used to move containers. Breakbulk cargo is carried by LCM8s. Lighters for "improved beach" operations[3] are the LCM8, the LCU, and the causeway ferry. The quantity of each type of lighter is also an input so that different lighter mixes can be simulated.

A containership with 300 containers is a typical input. The location of each container in a hatch and cell is specified. Similarly, the position of the general cargo on a breakbulk ship is defined.

The input information includes specifying distances. The distances from ship-to-shore, shore-to-marshalling area and shore-to-amphibian unloading site are specified.

The types of shoreside lighter unloading systems are also inputs. The beach crane, the inland crane, the elevated causeway, the LACH, and the B DeLong Pier can be simulated by proper specification of inputs to the model.

OUTPUTS

General

There are two primary outputs of the LOTS model of most direct interest: the overall time required for a specified amount of cargo to be moved from aboard ship to a marshalling area; and tabulations of the percentages of the total assigned lighters, trucks, and MHE that were actually used. The first measure, the overall time required, is extended when insufficient assets are assigned so that one or more critical subsystems are idle part of the time. On the other hand, when more than enough transport assets are assigned (i.e., lighters and trucks) the time measure becomes a constant minimum and the second primary output becomes useful. This output shows what percentages of each of the assigned transport were actually used. (The priority system used in the queues assures that already-used transport equipment is used first, so that statistics on assigned-but-not-used transport can readily be collected.

A set of summary statistics are printed at the end of each run. A table of statistics is given for the lighters, the trucks, the material handling equipment and the ships. The table for lighters gives the number of round trips from the ship to shore and the cargo carried. It also gives the time and percent of time spent in mooring and unmooring, loading and unloading, traveling to beach, traveling to ship, and the time spent in the queue

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[2] For details see Operations Research, Inc., Comment Draft Report on Main Test Design of the Joint Logistics-Over-The-Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 1132, 20 January 1977.

[3] Ibid.

at the shore and at the ship. The table for trucks is similar. A summary of material handling equipment utilization is also printed. The summary for the ships gives the time to off-load each hatch, total time to clear the ship, and all cargo to arrive at the marshalling area. In addition, the time the ship crane was idle, if any, is given.

Illustrative Examples

A series of computer runs were made to determine the number of lighters and the time required to discharge 300 containers from a containership under different scenario situations. The following are examples of simulated LOTS operations in the "bare beach" and "improved beach" phases of the main test.

Bare Beach Operations

For the bare beach phase of the test two crane subsystems were modeled for the unloading of containers: the crane-on-beach platform for unloading landing craft and a crane inland for unloading amphibians. Both cranes were assumed to operate full time. The lighters available for this phase of the test are two LACV-30s, four LARC-LXs, and at least 19 LCM8s. One LACV-30 and three LARC-LXs are assumed to be available for a full day of container operations, leaving one of each available as a back-up.

A series of computer runs were made to determine the number of lighters and the time required to discharge the 300 containers from the ship in the bare beach operation. The lighter mix consisted of amphibians and landing craft. Since the number of amphibians is limited, they were held constant at one LACV-30 and three LARC-LXs. At 1 nmi the number of LCM8s was varied and the time to discharge the ship was computed. The results of these runs are shown at the top of Table 6. The results show that a minimum time of 17.5 hr was reached when the number of LCM8s was increased to six; adding more LCM8s could not decrease this time. The LOTS system in this case was in near equilibrium with four amphibians being discharged at the crane inland and six landing craft at the crane on the beach.

TABLE 6

TIME TO DISCHARGE 300 CONTAINERS IN THE BARE BEACH OPERATION USING LCM8s IN THE LIGHTER MIX

Lighters			Distance of Ship Off-Shore (nmi)	Time to Discharge 300 Containers (hr)
LACV-30	LARC-LX	LCM8		
1	3	4	1	18.9
1	3	6	1	17.5
1	3	7	1	17.5
1	3	12	3.3	19.9
1	3	16	3.3	19.4
1	3	17	3.3	19.4

Another series of runs was made to estimate the effect of increasing ship-to-shore distance to 3.3 nmi. The results of these runs are shown in Table 6. The minimum time to discharge the ship was 19.4 hr which was reached when the number of LCM8s had been increased to 6; the total time increased to 19.9 hr when 12 LCM8s were tried. In general, increasing the distance from 1 nmi to 3.3 nmi increased the minimum time to discharge the ship from 17.5 hr to 19.4 hr, about 2 hr. The number of LCM8s had to be increased significantly— from 4 to 16— in order to keep the cranes on the ship busy. In this case, the system was getting out of balance as the proportion of containers moving to the two shoreside cranes was changing. The minimum of about 17½ hr cannot be achieved because the number of amphibians is fixed.

Improved Beach for Amphibious Forces

In the improved beach for amphibious forces phase of the main test the elevated causeway and the light-weight amphibious container handler (LACH) were modeled as system elements to off-load containers from lighters at the beach. As before, two cranes were modeled for off-loading the containership with a planned goal of 300 containers per day. One causeway ferry and two LCM8s were held fixed and the number of LCUs was varied in order to achieve a minimum throughput time.

As seen in Table 7 in the first run the ship was 1 nmi off-shore and the lighter mix consisted of one causeway ferry and two LCM8s and 1 LCU. In subsequent runs the number of LCUs was increased. A minimum time of 18.7 hr was computed to discharge the ship when the number of LCUs was increased to seven.

TABLE 7

TIME TO DISCHARGE 300 CONTAINERS IN THE IMPROVED BEACH FOR AMPHIBIOUS FORCES PHASE OF THE MAIN TEST

Lighters			Distance of Ship Off-Shore (nmi)	Time to Discharge 300 Containers (hr)
Causeway Ferry*	LCM8	LCU		
1	2	1	1	27.7
1	2	3	1	22.1
1	2	5	1	19.3
1	2	7	1	18.7
1	2	8	1	18.7
1	2	5	3.3	24.4
1	2	7	3.3	21.5
1	2	9	3.3	20.1
1	2	11	3.3	19.6
1	2	12	3.3	19.6

* Four causeway sections.

Next, the ship-to-shore distance was increased to 3.3 nmi. In this case when the number of LCUs was increased to 11 a minimum time of 19.6 hr was achieved. As in the bare beach operation, increasing the distance required a significant increase in the number of lighters but resulted in only a slight increase in total elapsed time.

SUMMARY

The LOTS simulation model has been improved and updated so that it can more accurately portray the operations planned for the LOTS test. As presently structured the primary use of the model has been to validate and refine test schedules, procedures, and resource requirements. In addition, the model will be used as a tool in the evaluation of test results; for example, to analyze the unloading of a fully loaded containership with two cranes-on-deck versus the test ship with only 600 containers aboard and one COD. In the future the LOTS simulation model can be used by the Services for analyses related to new operational concepts, new equipment being developed or procured, changes in unit structure, evaluation of movement and force requirements in support of selected contingency plans, and a host of possible "what ifs."

APPENDIX A

PROGRAM DESCRIPTION

An event-sequenced simulation technique is utilized in the programming of the LOTS model. Each LOTS element (i.e., ship, lighter, truck) is observed only when it is involved in a specified event. When an event occurs, the appropriate element is processed and the time of the next event, if any, is determined. For example, when a lighter arrives at the ship, event one has occurred. The lighter moors and is loaded, and the time for event two, lighter leaves the ship, is determined. The model next observes the lighter when event two occurs. To determine the next event to be processed, the event clock is searched and the event with the minimum time is selected.

An executive routine, see Figure A.1, searches the event clock, determines the next event, and transfers to the subroutine which processes the event that was found. If no event is found, program control is transferred to a subroutine, which prints an output summary, and the run is complete. Each event is processed in a separate subroutine named EVENT1, EVENT2, . . ., EVENT19, and described in Table A.1. In addition, a number of utility subroutines are used by the event subroutines as shown in Table A.2. A description of the utility subroutines is in Table A.3. After an event has been processed, control returns to the executive routine and the event clock is again searched.

Communication within the program is accomplished by means of 13 labeled common blocks. Each block generally contains the same category of variables, and a description of each common block is in Table A.4. Most variables in the common blocks are integers, therefore INTEGER*2 specifications can be used when running the program on an IBM computer. The INTEGER*2 statements reduce the core requirement by 40k bytes, thereby permitting a quicker turn around time on computers that give the highest priority to the smallest programs.

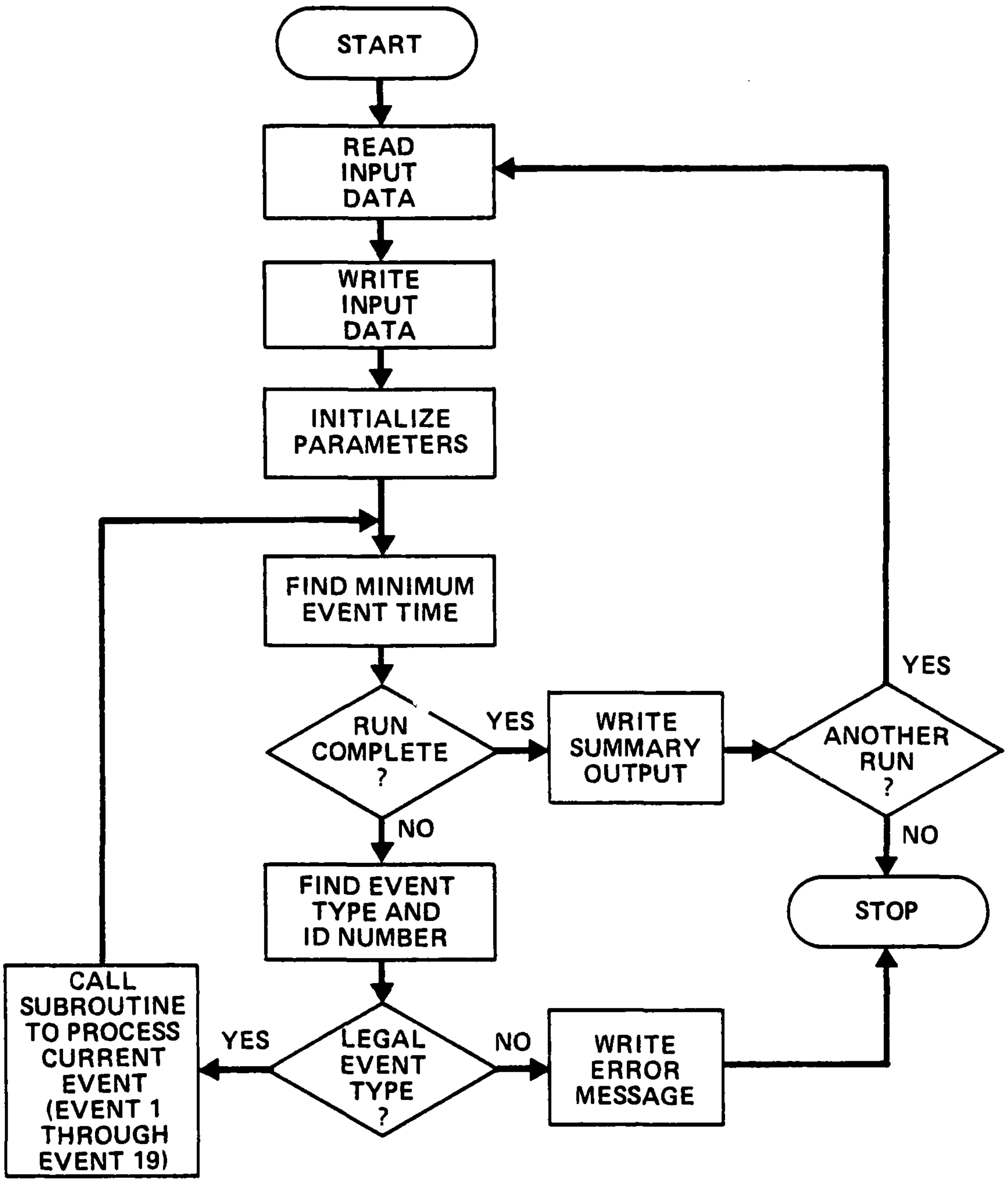

FIGURE A.1. EXECUTIVE ROUTINE LOGIC

TABLE A.1

SUMMARY DESCRIPTION OF EVENT SUBROUTINES

Subroutine	Summary Description
EVENT1	Lighter arrives at the ship
EVENT2	Lighter leaves the ship
EVENT3	Lighter arrives at the shoreside queue
EVENT4	Lighter arrives at the unloading site and unloading begins
EVENT5	Lighter unloading continues
EVENT6	Lighter leaves the unloading site and returns to queue at the ship
EVENT7	Truck leaves lighter unloading site
EVENT8	Truck arrives at the marshalling area
EVENT9	Truck leaves marshalling area
EVENT10	Fixed pier requires truck
EVENT11	Pier ready to discharge barge
EVENT12	Truck arrives at the shore queue
EVENT13	Self-deployable vehicle arrives at the marshalling area
EVENT14	Ship arrives
EVENT15	Lighter is required at the ship
EVENT16	Lighter remains at a unloading site for retrograde only
EVENT17	Fixed pier is ready for ship
EVENT18	Barge leaves pier
EVENT19	Lighter loading at the ship continues

TABLE A.2

UTILITY SUBROUTINES USED BY EVENT SUBROUTINES

Event Subroutines	Utility Subroutines
EVENT1	HSSORT, LDCONS, LDGCS, LOADEX
EVENT2	CRFDES, EVENT3, FNSSHS, HELPLT, HSSORT, MINCLK
EVENT3	TRKSEL
EVENT4	MINCLK
EVENT5	CLUSSL, EVENT4, TRKASG, TRKDES, TRKSEL, WATCRF, WATTRK
EVENT6	CLUSSL, MINCLK, SHPDEP, TRKASG, TRKDES, WATCRF, WATTRK
EVENT7	CLUSSL, TRKASG, TRKDES, WATCRF, WATTRK
EVENT8	TKUNLD
EVENT9	TRKASG, WATCRF, WATTRK
EVENT10	EVENT4, TRKASG, TRKDES, TRKSEL, WATCRF, WATTRK
EVENT11	EVENT4, TRKASG, TRKDES, TRKSEL, WATCRF, WATTRK
EVENT12	CLUSSL, TRKASG, WATCRF
EVENT13	MINCLK
EVENT14	HSSORT, MINCLK, SHPMOV
EVENT15	FNSSHS, HSSORT, MINCLK, SHPDEP
EVENT16	EVENT4, TRKASG, TRKDES, TRKSEL, WATCRF, WATTRK
EVENT17	CLUSSL, MINCLK, SHPDEP, TRKASG, TRKDES, WATCRF, WATTRK
EVENT18	CLUSSL, MINCLK, SHPDEP, TRKASG, TRKDES, WATCRF, WATTRK
EVENT19	HELPLT, HSSORT, LDCONS, MINCLK

TABLE A.3

SUMMARY DESCRIPTION OF UTILITY SUBROUTINES
USED BY EVENT SUBROUTINES

Subroutine	Summary Description
CLUSSL	Assigns waiting lighters in the shoreside queue to an unloading site.
CRFDES	Sends lighters from a ship to a shoreside queue.
FNSSHS	Opens a new hatch on a non-self-sustaining containership and closes empty hatches.
HELPLT	Places a container on the deck of a containership for helicopter pickup.
HSSORT	Sorts all unoccupied berths at the ship. A book-keeping subroutine.
LDCONS	Loads a lighter at a containership.
LDGCS	Loads a lighter at a general cargo ship.
LOADEX	Supervises the loading of lighters at a ship; calls LDCONS or LDCGS.
MINCLK	Updates event clock. A book-keeping subroutine.
SHPMOV	Assigns a temporary container discharge facility to a non-self-sustaining containership.
TRKASG	Assigns empty trucks for loading.
TRKDES	Sends trucks to the marshalling area.
TRKSEL	Selects the highest priority truck from the truck queue for a given cargo type.
TRUNLD	Unloads a truck at the marshalling area.
WATCRF	Assigns trucks or mobile material handling equipment to waiting lighters.
WATTRK	Assigns trucks waiting for unloading at the marshalling area.

TABLE A.4

DESCRIPTION OF LABELED COMMON

Labeled Common Number	Description
1	Event clocks
2	Cargo data
3	Lighter data
4	Truck data
5	Cargo hatch data
6	Number of elements (i.e., craft, trucks, ships) in system
7	LOTS system description data
8	Current location of cargo
9	Lighter selection data
10	Shipside unloading data
11	Status of ship unloading
12	Lighter unloading site data
13	Cumulative output statistics

All times within the program are expressed in seconds, with conversions to minutes and hours for input and output. Thus, time variables are integers and all internal time calculations use integer arithmetic which is faster than decimal arithmetic.